JOURNAL OF ANIMAL SCIENCE
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J Anim Sci 2002. 80:1166-1172.

Effect of removal and remixing of lightweight pigs on performance to slaughter weights[1,2,3]

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ABSTRACT: Two experiments were conducted to determine the effect of lightweight pig removal and remixing on performance to slaughter. Experiment 1 was a growing-finishing trial utilizing a total of 900 pigs (26.2 ± 0.1 kg initial weight) that were sorted and remixed at a mean replicate BW of 72 kg. Experiment 2 was a wean-to-finish trial (17 d mean wean age; 4.8 kg ± 0.1 BW) utilizing 225 barrows with sorting and remixing occurring 3 wk after weaning. Treatments were 15 pigs/pen from initial weight to slaughter (15S), 20 pigs/pen from initial weight to time of sort and remix and then reduced to 15 pigs/pen (20/15), and 15 pigs/pen from time of sort and remix to slaughter comprised of the five lightest pigs from each of three 20/15 pens per replicate (15M). Space allocation was 0.56 m^2/pig from 26 to 70 kg and 0.74 m^2/pig thereafter in Exp. 1. In Exp. 2, pen size was fixed at 2.44 × 4.27 m. In Exp. 1, there was no effect ($P > 0.20$) of treatment on performance prior to 70 kg. Least squares means for ADG from time of sort and remix to first pig removal from a pen for slaughter at 113 kg were 0.93, 0.87, and 0.91 kg/d for the 20/15, 15M, and 15S treatments, respectively ($P < 0.05$). When comparing the population represented by the 20/15 + 15M treatments vs the 15S population, there was no difference ($P > 0.20$) in ADG, ADFI, feed conversion, or carcass lean content. In Exp. 2, pigs in the 20/15 treatment grew slower ($P < 0.05$) than 15S pigs for the first 21 d (0.20 vs 0.22 kg/d, respectively) with a lower ADFI ($P = 0.06$) and no difference in feed conversion. When comparing the population represented by the 20/15 + 15M treatments vs the 15S population after sorting and remixing, there was no effect ($P > 0.15$) of experimental treatments on ADG, ADFI, feed conversion efficiency, carcass lean content, or daily lean gain. These results suggest that removal of lightweight pigs and remixing of the removed pigs into pens of similar-weight pigs is ineffective in improving the overall performance of a population of pigs during the postweaning period.

Key Words: Finishing, Growth, Mixing, Pigs

 J. Anim. Sci. 2002. 80:1166–1172

Introduction

Managing variation in weight in nursery and grow-finish facilities has major economic impacts for producers who market slaughter weight pigs to a slaughterhouse which has severe discounts for pigs which weigh more or less than the slaughterhouse-defined ideal. Payne et al. (1999) reviewed a variety of factors that affect variation in pig weight and suggested that a coefficient of variation of 10% was a reasonable benchmark for live weight when first marketing occurs from groups formed from pigs within 1 wk of age. Research on possible management techniques to reduce variation is limited. The NCR-89 Committee on Confinement Management of Swine (1992) reported that pigs identified as having slow growth rates

[1]Published as Journal series no. 13489, Agric. Res. Div., Univ. of Nebraska.

[2]Supported in part by a grant from Elanco Animal Health, Indianapolis, IN.

[3]Appreciation is expressed to Wanda Kreikemeier for data summarization and statistical analysis.

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Received September 26, 2001.
Accepted January 25, 2002.

Table 1. Cooperating experiment stations, number of replications, and floor type (Exp. 1)

Station	Replications	Full or partial slats
Illinois	2	Full
Iowa	2	Partial
Michigan	2	Full
Minnesota	4	Full
Nebraska	2	Partial

during the grow-finish phase did not respond differentially to a growth-promoting feed additive regimen.

Both Tindsley and Lean (1984) and O'Quinn et al. (2001) reported that sorting pigs into finishing pens by uniform weight groups (i.e., reduced within-pen weight variation) was not effective in improving overall performance to slaughter weight. O'Quinn et al. (2001) suggested that pigs grow to a common end-point variability, reducing the need for initially sorting by BW. However, no data are available on the impact of reducing variability during the growing period by removal and remixing of the lightweight pigs. Two experiments were conducted to determine the effect of removing lightweight pigs from pens and remixing them with similarly sized pigs on performance to slaughter weight of populations of pigs.

Materials and Methods

Experiment 1

Five experiment stations in the north-central region of the United States cooperated in this experiment. Station identification, number of replications, and floor type are presented in Table 1. Within stations with partially slatted pens, the ratio of slatted floors to solid floors was similar across treatments.

Experimental treatments were 1) 15 pigs/pen from initial weight to slaughter (**15S**), 2) 20 pigs/pen from initial weight to 70 kg BW and then reduced to 15 pigs/pen to slaughter (**20/15**), and 3) 15 pigs/pen from 70 kg mean replicate BW to slaughter comprised of the five lightest pigs from each of three 20/15 pens per replicate (**15M**). Thus, each full replication of experimental treatments consisted of one pen of 15S, one pen of 15M, and three pens of 20/15 treatments.

On the week the mean BW of a replicate averaged 70 kg or greater, the five lightest pigs were removed from each of the three 20/15 treatment pens in the replicate, and the 15 removed pigs were combined into a new pen (15M). The removal of five pigs from the 20/15 pen increased space allocation from 0.56 to 0.74 m^2/pig and the 15M were given 0.74 m^2/pig. At the same time, the space allocation of the 15S treatment was increased from 0.56 to 0.74 m^2/pig by adjusting one or more pen partitions within the station. Pen size was adjusted to maintain space allocation in the event of pig removal or death.

Within a station, there was a minimum of one feeder space per eight pigs and two nipple drinkers or one cup drinker per pen. All pigs were provided ad libitum access to diets and diets were switched on the week the mean replicate weight was 36, 59, and 86 kg.

Diets for barrows were formulated from corn and soybean meal with no added fat to contain the following lysine levels: 1.00% lysine from 26 to 36 kg, 0.88% lysine from 36 to 59 kg, 0.73% lysine from 59 to 86 kg, and 0.60% lysine from 86 kg to slaughter. Diets for gilts and mixed-sex pens were formulated to contain 1.00, 0.93, 0.88, and 0.69% lysine respectively.

All diets met or exceeded NRC (1998) recommendations for vitamin and mineral additions. Tylosin (Elanco Animal Health, Indianapolis, IN) was added at 44 mg/kg to the diets from 26 to 59 kg BW and at 22 mg/kg from 59 kg BW to slaughter.

Illinois, Michigan, and Minnesota used pens of mixed sexes with a ratio of three gilts and two barrows for a total of 12 gilts and 8 barrows in the 20/15 treatment and 9 gilts and 6 barrows in the 15S treatment. At 70 kg, the three lightest gilts and two lightest barrows were removed from the 20/15 treatment to maintain the constant sex ratio. Iowa used a ratio of three barrows and two gilts, and Nebraska used all barrows.

Pigs were removed for slaughter on the week they weighed 113.6 kg or greater. Pen size was not adjusted after removal of pigs at this weight. Beginning the week when 50% or more of the pigs had been removed from a pen, the remaining pigs were fed as a group for up to 3 wk or until the pen averaged 113.6 kg. Carcass lean percentage was estimated within station either from slaughterhouse data on individually identified pigs (Illinois and Minnesota) or real-time ultrasound scan at time of removal for slaughter (Iowa and Michigan).

Experiment 2

The same experimental treatments as in Exp. 1 were applied to 225 Danbred (Danbred USA, Seward, NE) barrows at weaning to determine the effect of removal and remixing 3 wk after weaning on performance in a wean-to-finish facility.

After weaning at an average age of 17 d, barrows (4.8 kg BW) were transported 375 km from a southwestern Minnesota farrowing facility to the University of Nebraska's Northeast Research and Extension Center at Concord. Immediately after arrival, the newly weaned pigs were weighed, ear-tagged, and randomly assigned to experimental treatments on the basis of BW outcome groups. Weight blocks were not used so as to increase within-pen weight variation. There were three treatment replications with five pens per replication for a total of 15 pens following removal of the lightweight pigs and remixing 21 d after weaning.

Pigs were housed in a fully slatted, naturally ventilated wean-to-finish facility (Brumm et al., 2002).

Table 2. Experimental diets for Exp. 2 (as-fed basis)

	Pig weight, kg							
Item	5.9 to 8.2	8.2 to 11.4	11.4 to 18	18 to 27	27 to 41	41 to 61	61 to 86	86 to Mkt.
Ingredient, %								
Corn	46.00	55.25	59.75	60.85	64.75	68.60	77.40	85.00
Soybean meal (46.5% CP)	20.50	26.25	32.25	33.50	29.75	26.25	18.50	12.00
Fat[a]	1.00	1.00	3.00	3.00	3.00	3.00	2.00	1.00
Limestone				1.25	1.10	0.80	0.75	0.70
Dicalcium phosphate				0.85	0.85	0.80	0.80	0.75
Salt				0.30	0.30	0.30	0.30	0.30
Vitamin and trace mineral premix[b]				0.20	0.20	0.20	0.20	0.20
L-Lysine·HCl				0.05	0.05	0.05	0.05	0.05
Prestart 650 base[c]	32.50							
Start 350 base[c]		17.50						
Start 100 base[c]			5.00					
Calculated composition								
Lysine, %	1.44	1.37	1.31	1.20	1.10	1.00	0.80	0.62
Ca, %	0.79	0.78	0.80	0.75	0.70	0.60	0.56	0.51
P, %	0.69	0.67	0.68	0.62	0.58	0.51	0.47	0.43

[a]CW-3800, Feed Energy Co., Des Moines, IA.
[b]Provided the following (per kilogram of complete diet): vitamin A, 5,500 IU; vitamin D_3, 1,100 IU; riboflavin, 4.4 mg; niacin, 26.4 mg; D-pantothenic acid, 17.6 mg; choline chloride, 76 mg; vitamin E, 24 IU; vitamin K, 2.2 mg; vitamin B_{12}, 26 μg. Provided the following minerals in the complete diet (parts per million): Zn, 90; Fe, 80; Mn, 32; Cu, 100; I, 0.4; Se, 0.3.
[c]Carl Akey Inc., Lewisburg, OH.

Each pen contained a two-hole wean-to-finish feeder and one cup drinker. Each pen measured 2.4 × 4.7 m and pen size was not adjusted at the time of pig removal or in the event of pig death or removal. This provided 0.52 m^2/pig at 20 pigs/pen and 0.69 m^2/pig at 15 pigs/pen.

At arrival, pigs were fed 1 kg/pig of a commercial pelleted diet (Akey 2000, Carl Akey Inc., Lewisburg, OH) containing 440 mg/kg of chlortetracycline (Alpharma, Ft. Lee, NJ) and 39 mg/kg of thiamulin (Boehringer Ingelheim Vetmedica, St. Joseph, MO). Following this, all diets were in meal form (Table 2). Diets contained 55 mg/kg of carbadox (Pfizer, Exton, PA) to 27 kg BW, 44 mg/kg of tylosin from 27 to 61 kg, and 22 mg/kg thereafter.

On d 158 following weaning, all pigs weighing 116 kg or greater were removed for slaughter. The remaining pigs were removed for slaughter on d 172 after weaning. Pigs were slaughtered at IBP Inc., Madison, NE and carcass percentage lean was reported on individually identified pigs. Lean gain from 61 d after weaning to slaughter was calculated according to NPPC (1991).

Statistical Analysis

The pen of pigs was considered the experimental unit for statistical analysis in both experiments. Analysis of variance was conducted using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC). In Exp. 1, the error mean square of the station × treatment interaction was used as the error term to test treatment effects, and the treatment × replication within station error mean square was used to test the station × treat-

Table 3. Least squares means (± SE) for effect of experimental treatments on pig performance to 72 kg BW (Exp. 1)

	Treatment[a]		*P*-value	
Item	20/15	15S	Treatment	Station
No. of pens	36	12		
Pig weight, kg				
Initial	26.2 (0.09)	26.2 (0.15)	0.772	<0.001
Sort/removal	72.9 (0.76)	70.8 (1.32)	0.236	0.002
Coefficient of variation (pig weights within pen)				
Initial	13.4 (0.32)	13.3 (0.56)	0.869	0.019
Sort/removal	10.2 (0.52)	11.4 (0.91)	0.317	0.084
Average daily gain, kg	0.795 (0.008)	0.788 (0.014)	0.649	0.001
Average daily feed intake, kg	2.025 (0.018)	2.037 (0.032)	0.763	0.001
Gain:feed	0.395 (0.003)	0.388 (0.005)	0.305	0.002

[a]20/15 = 20 pigs/pen; 15S = 15 pigs/pen.

Table 4. Least squares means (± SE) for effect of pig removal and remixing on pig performance (Exp. 1)

Item	Treatment[a]			*P*-value		
	20/15	15M	15S	Treatment	Station	20/15 + 15M vs 15S
Pig weight, kg						
Sort/removal	74.1 (1.0)	61.6 (1.7)	70.8 (1.6)	<0.001	0.001	0.166
First marketed	101.2 (1.1)	101.2 (1.9)	100.4 (1.9)	0.925	0.004	0.709
Final[b]	115.9 (0.4)	114.8 (0.7)	116.7 (0.7)	0.205	0.051	0.135
Coefficient of variation (pig weights within pen)						
Sort/removal	9.2 (0.5)	8.6 (0.9)	11.4 (0.9)	0.117	0.003	0.044
First marketed	8.2 (0.4)	8.7 (0.6)	10.2 (0.6)	0.073	<0.001	0.043
Average daily gain, kg						
Sort to first marketed	0.932 (0.009)	0.872 (0.016)	0.907 (0.016)	0.037	0.001	0.798
Sort to final[b]	0.954 (0.006)	0.892 (0.011)	0.934 (0.011)	0.008	<0.001	0.411
Average daily feed intake, kg						
Sort to first marketed	3.142 (0.030)	2.892 (0.52)	3.049 (0.052)	0.009	0.001	0.612
Sort to final[b]	3.190 (0.029)	2.900 (0.50)	3.122 (0.050)	0.007	<0.001	0.227
Gain:feed, kg/kg						
Sort to first marketed	0.298 (0.004)	0.303 (0.007)	0.299 (0.007)	0.858	0.002	0.820
Sort to final[b]	0.302 (0.004)	0.309 (0.006)	0.301 (0.006)	0.560	<0.001	0.514
Carcass lean, %[bc]	52.7 (0.1)	52.3 (0.2)	52.7 (0.2)	0.180	<0.001	0.378

[a]20/15 = 20 pigs/pen reduced to 15 by removal of lightest five at 70 kg; 15M = 15 pigs/pen comprised of five lightest from each of three 20/15 pens; 15S = 15 pigs/pen from start to slaughter.
[b]Data from IL, IA, MI, and MN only.
[c]Containing 5% fat.

ment interaction. The orthogonal contrast of 20/15 + 15M vs 15S was examined to test whether population differences existed for the two management schemes in Exp. 1 and 2.

Results

Experiment 1

There was no effect ($P > 0.20$) of experimental treatments on pig performance prior to removal of the lightest pigs from the 20/15 treatment (Table 3). With space constant at 0.56 m^2/pig, there was no effect of 20 vs 15 pigs per pen on gain or feed conversion efficiency. When the experiment was designed, the goal was to have the initial CV of within-pen weight in the range of 15 to 20%. The initial CV averaged 13% across all replications. This decreased to 10 to 11% by 70 kg BW.

After removal of the five lightest pigs from three pens and remixing to create a pen of the 15 lightest pigs within a replicate, within pen CV decreased to 8 to 9% (Table 4). Within-pen CV were lower for the 20/15 + 15M population of pigs than for the 15S population when the first pig was removed from a pen for slaughter ($P < 0.073$). There was no effect of treatment ($P = 0.71$) on average weight when the first pig in a pen was removed for slaughter. There was also no treatment effect ($P = 0.14$) on final weight for the four stations reporting this variable.

The University of Nebraska was unable to remove pigs for slaughter according to the materials and methods described for Exp. 1. Thus, performance for the time period identified as sort to first market in Table 4 includes 12 replications whereas performance associated with the time period sort to final, which includes carcass lean measurements, is based on 10 replications.

There are treatment effects noted for daily gain and daily feed intake for both time periods cited in Table 4. However, when comparing the population of pigs represented by the 20/15 treatment plus the 15M treatment with the population represented by the 15S treatment, there were no differences in any measurement reported, other than the within-pen variation in weight already discussed.

Experiment 2

Unlike in Exp. 1, there was an effect of treatment for the first 21 d following weaning (Table 5). Pigs in the 15S treatment weighed more ($P < 0.05$) because of a higher daily gain ($P < 0.05$) due to a higher feed intake ($P = 0.06$). There was no effect of treatment on feed conversion efficiency. There was no effect ($P > 0.10$) of treatment on within-pen weight variation at the end of the 21-d period.

After removal of the lightest five pigs from the 20/15 treatment pens, within-pen weight variation decreased ($P < 0.005$) for the 20/15 + 15M population compared with the 15S population (Table 6). Because the 15M pen contained the lightest pigs on d 21 following weaning, the pen average weight was also the lightest on d 61 and d 158. Final weight for this treatment was lowest due to the method used to market the pigs.

Table 5. Least squares means (± SE) for effect of experimental treatments on pig performance 21 d after weaning (Exp. 2)

Item	Treatment[a] 20/15	15S	P-value for treatment
No. of pens	9	3	
Pig weight, kg			
Initial	4.8 (0.03)	4.8 (0.05)	0.448
d 21	9.0 (0.11)	9.5 (0.20)	0.047
Coefficient of variation (pig weights within pen)			
Initial	15.7 (0.5)	17.2 (0.8)	0.132
d 21	19.5 (0.8)	17.0 (1.4)	0.140
Average daily gain, kg	0.196 (0.005)	0.223 (0.009)	0.029
Average daily feed intake, kg	0.278 (0.006)	0.303 (0.010)	0.060
Gain:feed	0.707 (0.015)	0.737 (0.027)	0.347

[a]20/15 = 20 pigs/pen; 15S = 15 pigs/pen.

When comparing the population of 20/15 + 15M vs 15S, there was no effect of treatment on within-pen weight variation, daily gain, daily lean gain, carcass lean percentage, or daily feed intake. For the period from d 21 to 61, 15S pigs had an improved ($P < 0.05$) gain:feed ratio and the 20/15 + 15M population had a higher ($P = 0.07$) efficiency for the period from d 21 to 158, primarily due to the improvement during d 61

Table 6. Least squares means (± SE) for effect of pig removal and remixing on pig performance (Exp. 2)

Item	Treatment[a] 20/15	15M	15S	P-value Treatment	20/15 + 15M vs 15S
No. of pens	9	3	3		
Pig weight, kg					
d 21	9.7 (0.1)	7.0 (0.2)	9.5 (0.2)	<0.001	0.001
d 61	29.7 (0.3)	25.5 (0.6)	25.8 (0.6)	<0.001	0.110
d 158	116.9 (0.5)	110.5 (0.9)	115.1 (0.9)	<0.001	0.234
Final	123.0 (0.7)	118.4 (10.3)	121.3 (1.3)	0.027	0.715
Coefficient of variation (pig weights within pen)					
d 21	13.7 (0.6)	11.3 (1.1)	17.0 (1.1)	0.009	0.003
d 61	11.7 (0.7)	12.7 (1.1)	11.4 (1.1)	0.689	0.571
d 158	7.6 (0.6)	7.9 (1.0)	6.9 (1.0)	0.732	0.443
Average daily gain, kg					
d 21 to 61	0.503 (0.008)	0.461 (0.013)	0.484 (0.013)	0.047	0.909
d 61 to 158	0.899 (0.005)	0.878 (0.008)	0.891 (0.008)	0.134	0.833
d 21 to 158	0.783 (0.004)	0.756 (0.006)	0.771 (0.006)	0.009	0.809
d 21 to final	0.749 (0.004)	0.721 (0.006)	0.742 (0.006)	0.007	0.347
d 61 to final	0.896 (0.006)	0.863 (0.010)	0.891 (0.010)	0.051	0.378
Average daily feed intake, kg					
d 21 to 61	0.912 (0.020)	0.730 (0.035)	0.869 (0.035)	0.003	0.258
d 61 to 158	2.743 (0.027)	2.709 (0.047)	2.654 (0.047)	0.028	0.200
d 21 to 158	2.042 (0.017)	1.896 (0.029)	2.020 (0.029)	0.003	0.153
d 21 to final	2.003 (0.015)	1.890 (0.026)	1.991 (0.026)	0.008	0.157
d 61 to final	2.557 (0.020)	2.445 (0.034)	2.478 (0.034)	0.028	0.572
Gain:feed					
d 21 to 61	0.552 (0.007)	0.632 (0.013)	0.559 (0.013)	0.001	0.041
d 61 to 158	0.328 (0.003)	0.324 (0.005)	0.336 (0.005)	0.241	0.100
d 21 to 158	0.383 (0.002)	0.399 (0.004)	0.382 (0.004)	0.013	0.067
d 21 to final	0.374 (0.002)	0.382 (0.004)	0.373 (0.004)	0.246	0.303
d 61 to final	0.350 (0.002)	0.353 (0.004)	0.360 (0.004)	0.189	0.120
Carcass lean, %[b]	54.4 (0.1)	54.1 (0.2)	54.5 (0.2)	0.242	0.276
Lean gain, kg/d[b]	0.343 (0.002)	0.328 (0.004)	0.336 (0.004)	0.026	0.832

[a]20/15 = 20 pigs/pen reduced to 15 by removal of lightest five pigs 21 d after weaning; 15M = 15 pigs/pen comprised of five lightest from each of three 20/15 pens; 15S = 15 pigs/pen from weaning to d 158.
[b]Containing 5% fat.

to 158 ($P = 0.1$). From 21 d after weaning to slaughter, there was no effect of treatment on feed conversion efficiency.

Discussion

Payne et al. (1999) described variation in performance as a very real, but often hidden, cost to the pork industry that is difficult to quantify. There has been considerable research on the impact of weight variation on weaned pig and growing-finishing pig performance. Tindsley and Lean (1984) and O'Quinn et al. (2001) concluded that allotting finishing pigs to pens on the basis of weight to minimize within-pen weight variation did not reduce overall variation in final weight or improve facility utilization. Similarly, Frances et al. (1996) reported inconsistent responses when mixing newly weaned pigs into uniform weight groups. McGlone et al. (1987) reported no difference in weaned pig performance between groups of pigs that had small, medium, and large within-pen initial BW variation. They concluded that at thermoneutral temperature, smaller pigs gained more weight when in pens with larger pigs. Using groups of 10 pigs per pen, Spoolder et al. (2000) reported no effect on daily gain or feed conversion efficiency from mixing pigs at 75 kg vs not mixing. Although mean performance was cited, there were no data on weight variation within a pen or population.

Heetkamp et al. (1995), citing Hessing et al. (1994), concluded that when groups of pigs are created based on BW criteria, both active and passive copers in terms of dealing with mixing stress are brought together. Hyun et al. (1998) concluded the effect of mixing on patterns of feed intake was relatively short with no effect on overall growth to slaughter.

The lack of effect of group size prior to removal and remixing in Exp. 1 (Table 3) vs the depression in daily gain for the 20 vs 15 treatment for the initial 3-wk period of Exp. 2 (Table 5) may be related to the age (size) of pig. Kornegay and Notter (1984) reported a larger correlation coefficient for the relationship of group size and performance for weaned pigs vs grower and finisher pigs. Others have reported inconsistent effects of group size for growing-finishing pigs (Randolph et al., 1981; Petherick et al., 1989; Walker, 1991). Most recently, Wolter et al. (2001) reported that the effects of group size on growth were greatest for small pigs.

Wolter et al. (2000) suggested that as group sizes increase in pens of weaned pigs, social facilitization may result in relatively more pigs wanting to eat at the same time, thereby increasing the competition for feeder space. In Exp. 2, the number of feeder spaces (each space provided 33 cm of trough length) was not varied and may have contributed to the decrease in performance noted.

It is possible that the change in pen social structure, whether pen space was constant across all treatments (Exp. 1) or whether pen size was constant (Exp. 2), caused variation to increase to a level similar to what it would have been with no pig removal. This possibility of a natural increase in variation is supported by the sharp decrease in variation for the 15S treatment in Exp. 2 on d 61 vs d 21 when compared with little change in variation for the 20/15 and 15M pens.

Implications

Results of these experiments support the conclusion that removal and remixing of lightweight pigs does not improve performance or decrease population variation at market weight. It is possible that results may have been different if the lightweight, remixed pigs had been offered a diet formulated to more closely match their nutritional needs vs a diet formulated to the average needs of the population. Results may also differ if the heaviest or midweight pigs are removed and remixed and such comparisons merit further investigation.

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